



**HYDRO
GEOCHEM
GROUP**

GREENROAD GROUP

Responding to increased climate risk

Jim Griffiths, Hydro Geochem Group.

AusIMM 2025



Responding to increased climate risk

Increasing requests to assess impact of climate change.

Review of methods and guidance materials in NZ.

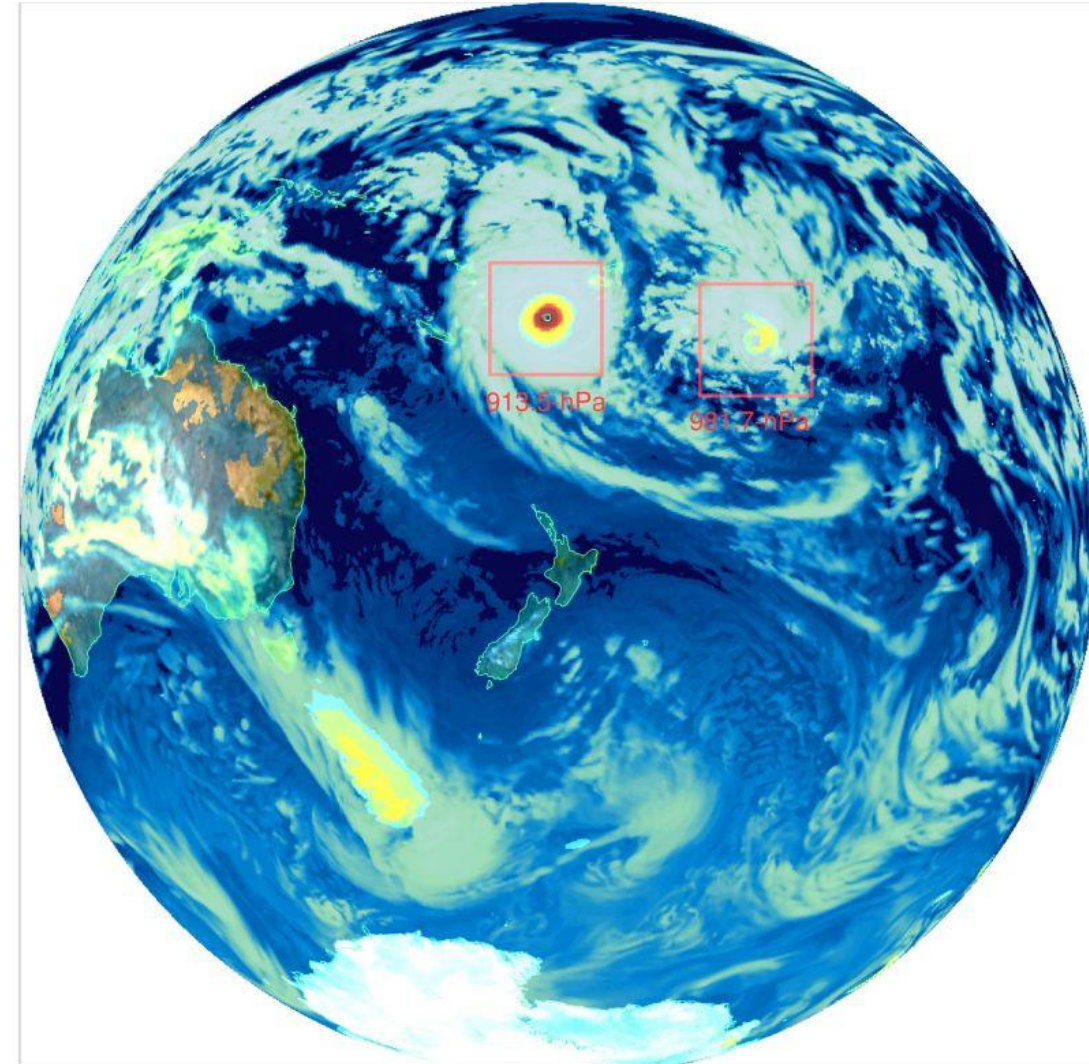
Specific concerns for the mining industry:

water resources, flood risk, slope stability and erosion processes

Potential mitigations

Take-away messages

Impacts and evidence of climate change



Downscaled Climate Projections of Tropical and Ex-Tropical Cyclones Over the Southwest Pacific *Journal of Geophysical Research: Atmospheres*

Responding to climate change

Guidance materials:

National Climate Change Risk Assessment for New Zealand, **2020**.

Guide to local climate change risk assessment, **2021**.

New Zealand's First National Adaptation plan – Adapt and Thrive, **2022**.



Regional downscaling methods and strategies

Most water management decisions are taken at the regional or sub-regional scale

Flood risk and planning

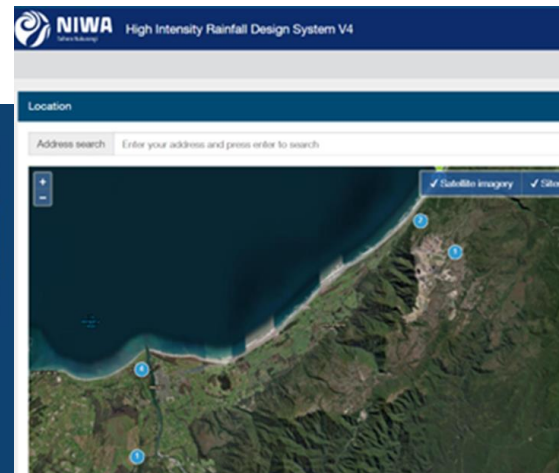
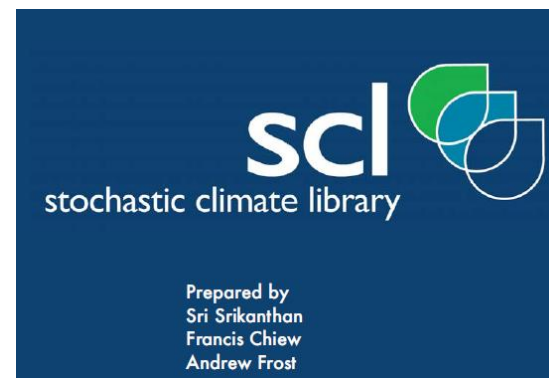
Stormwater and erosion management

Water storage needs

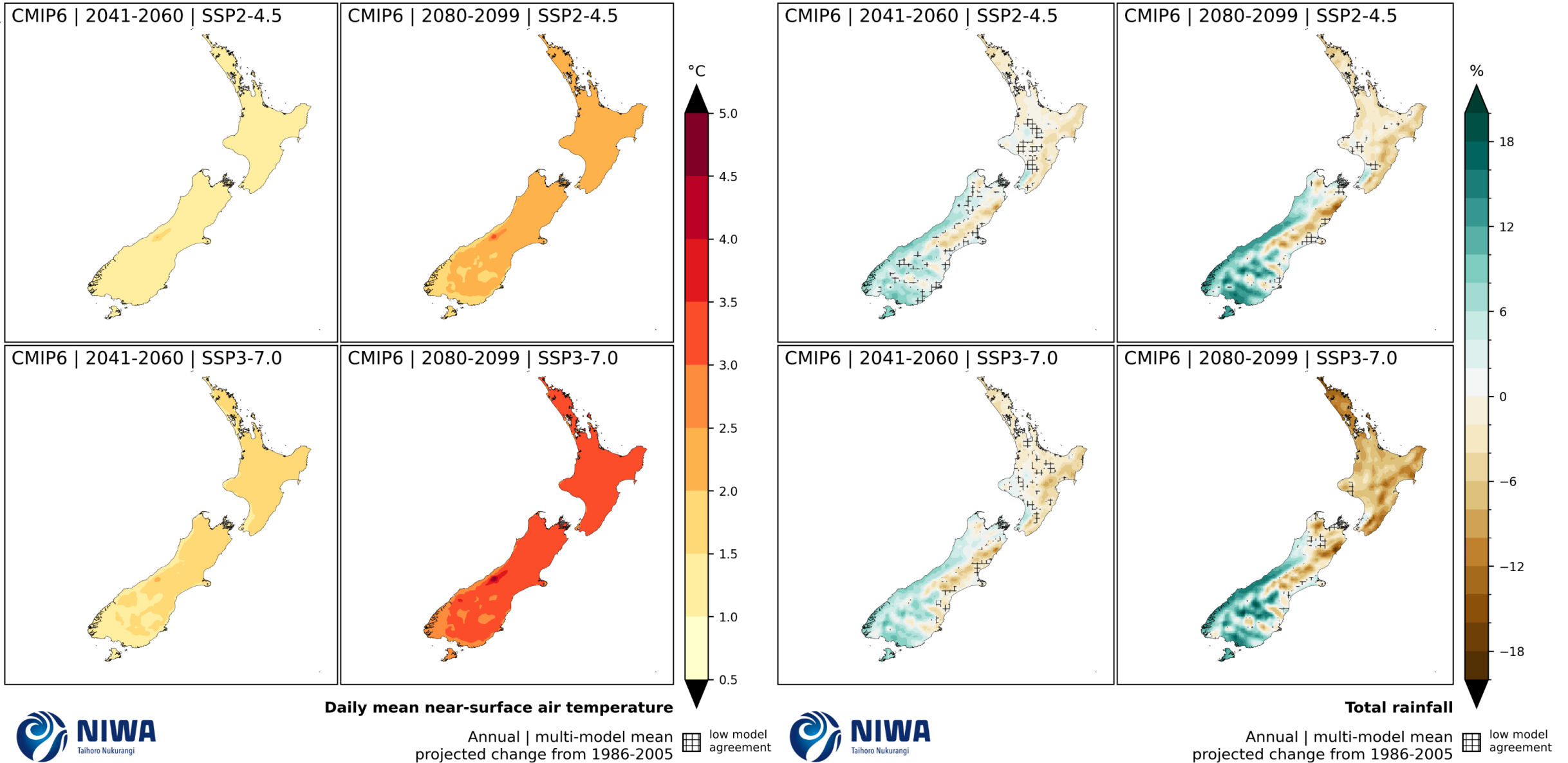
Water demand estimation

Landcover impacts

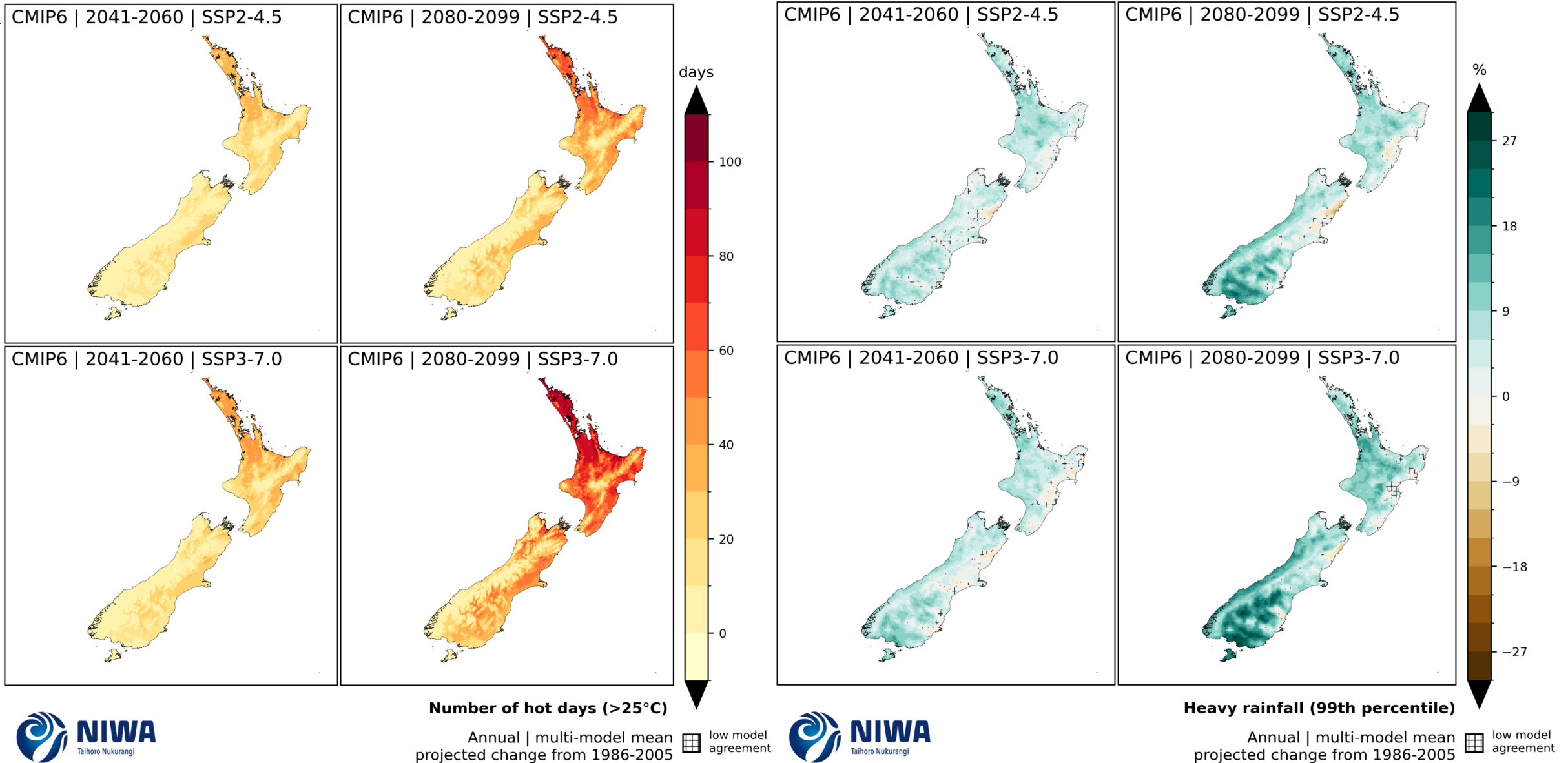
Mine closure planning



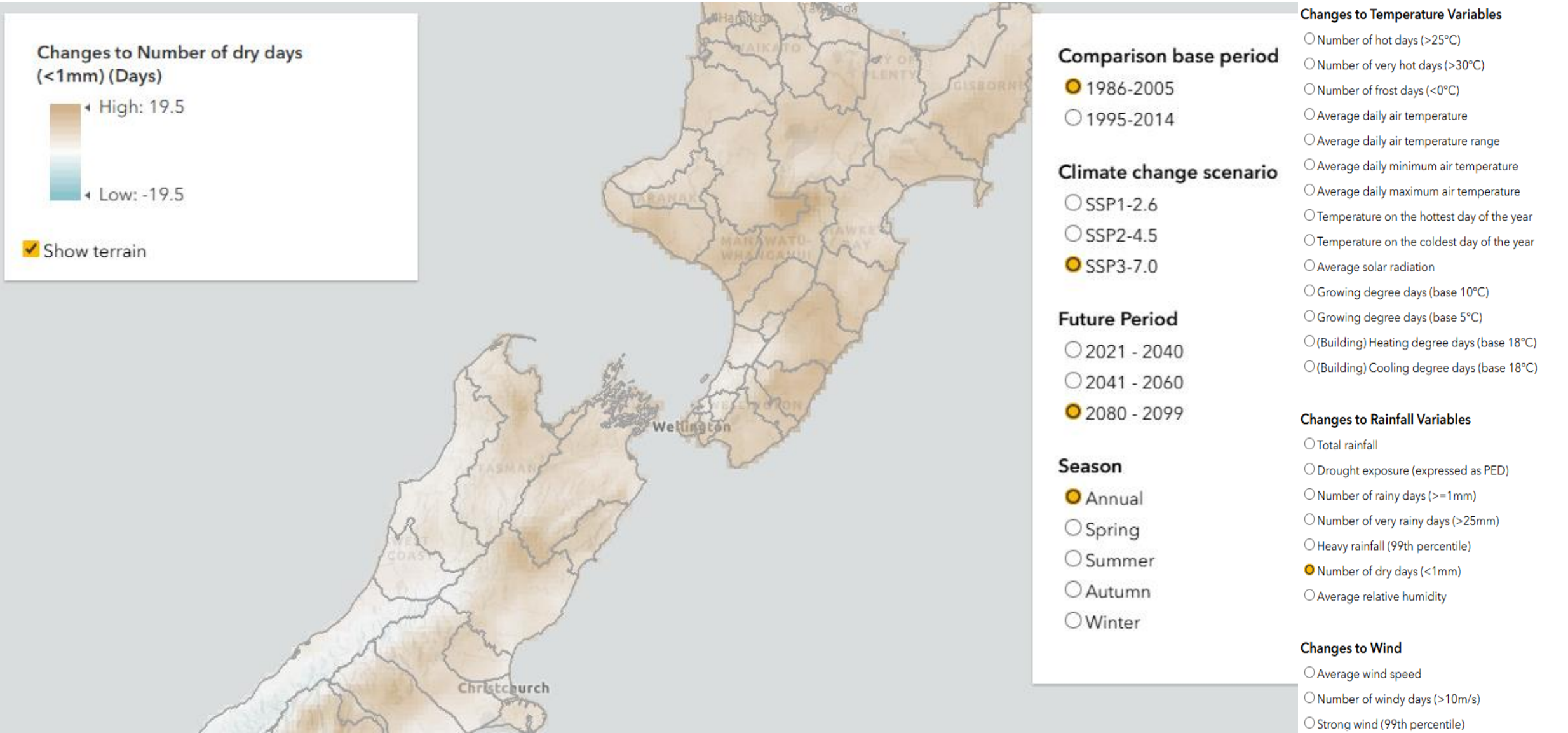
NIWA regional climate change scenarios



NIWA regional climate change scenarios



National climate change projections



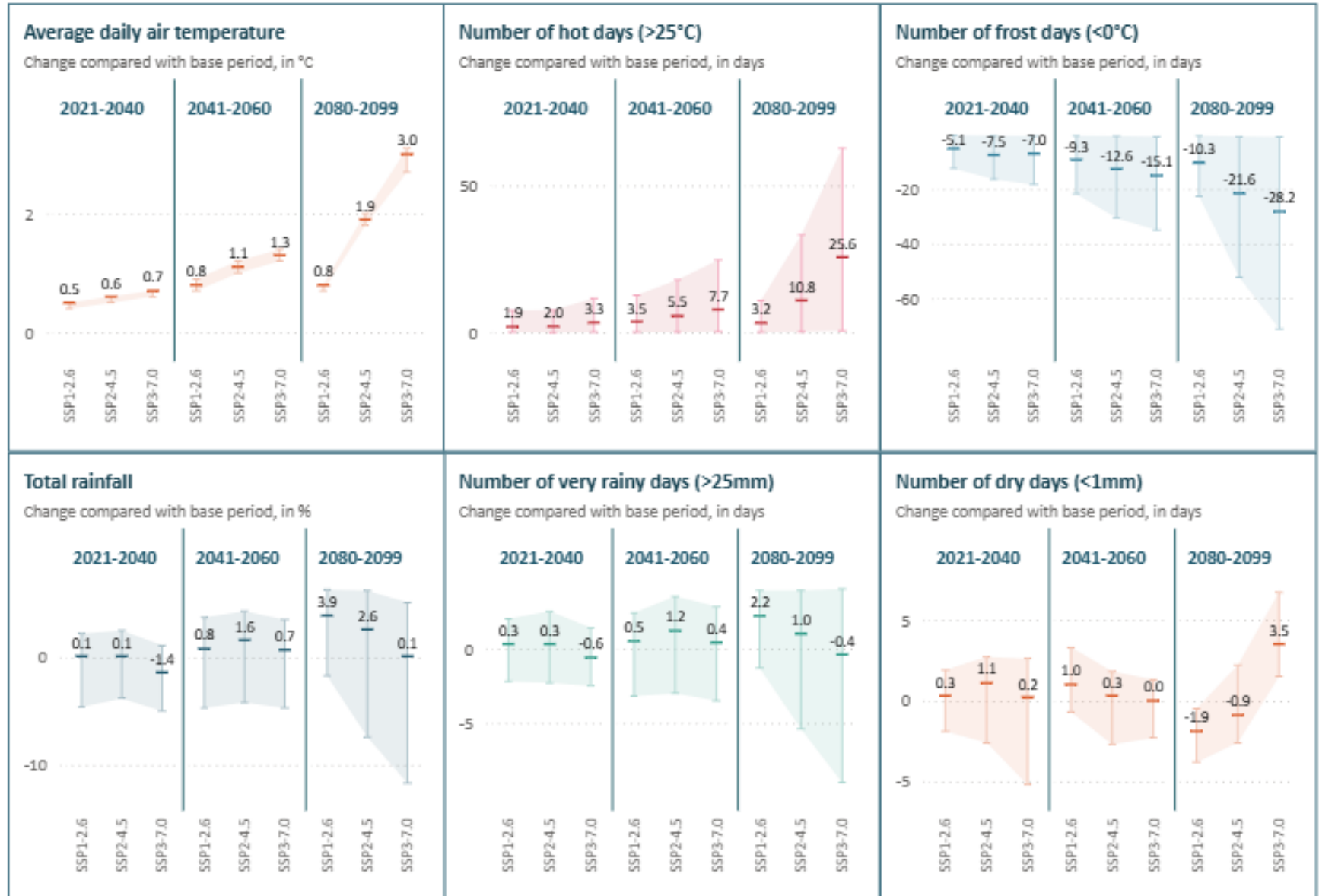
National climate change projections

Territorial Authority

Buller District

This summary provides an overview of how the climate is projected to change in **Buller District** between now and 2099 and presents projections as a range of values from a low emissions to a high emissions future.

These projections are relative to the **1995-2014** period and consider a range of scenarios for future climate change as defined by the Intergovernmental Panel on Climate Change (IPCC).



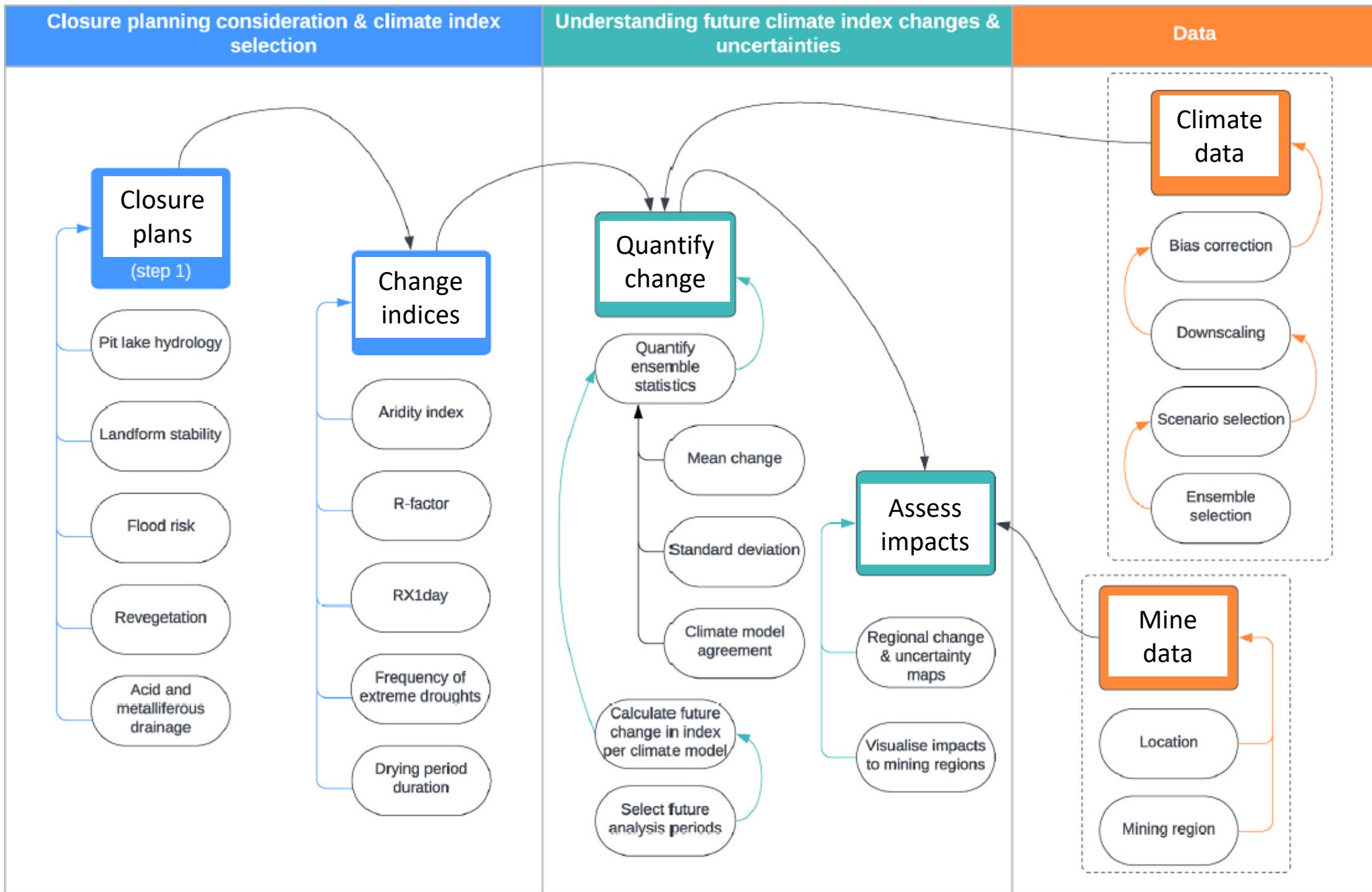
[Climate projections summary dashboard](#)
Ministry for the Environment

NIWA regional climate scenarios

Zone 4: Regional snapshot of projected climate changes and hazards Northern South Island (Te Wai Pounamu) – covers Marlborough (from Kaikōura north), Nelson (Whakatū) and around to Punakaiki on the West Coast. Includes Tasman, Nelson, Marlborough and Buller District.			
Hazard	RCP 4.5	RCP8.5	Extra information
Higher mean temperatures: air and water	2040: Annual average air temp to increase 0.7-0.9°C Coastal sea-surface temps to increase ~1°C (7% change).	2040: Annual average air temp to increase 0.8-1.1°C Coastal sea-surface temps to increase ~1.3°C (9% change).	<ul style="list-style-type: none"> - Summer air temperature to warm the most; Spring air temperature the least. - Daily maximum air temperature is expected to increase faster than overnight daily minimum temperature. - Tasman Sea (Zones 2-3) expected to show the largest absolute sea temperature change: warming to exceed 1.3°C (RCP4.5, ~2100) or 3.1°C (RCP8.5, ~2100).
	2090: Annual average air temp to increase 1.3-1.4°C, Coastal sea-surface temps to increase ~1.1°C (8% change).	2090: Annual average air temp to increase 2.8-3.1°C Coastal sea-surface temps to increase ~2.8°C (20% change).	
Heatwaves: increasing frequency and magnitude	2040: Increase 0-15 more hot days/year (>25°C).	2040: Increase 0-10 more hot days/year (>25°C). Highest in Marlborough valleys.	<ul style="list-style-type: none"> - No data available yet for Heatwaves >25°C (3 consecutive days) or Extreme Heatwaves >30°C (3 consecutive days). - 40-100% increase in hot days (>25°C) across New Zealand (RCP4.5, ~2050). - 40-300% increase in hot days (>25°C) across New Zealand (RCP4.5, ~2100).
	2090: Increase 5-20 more hot days/year (>25°C). Highest in Marlborough valleys	2090: Increase 5-35 more hot days/year (>25°C). Highest in Marlborough/Tasman valleys.	

Impacts on mining operations

Change	Risk	Affected Processes	Impacts	Adaptation / Mitigation
Variability and intensity of drought and flood	<ul style="list-style-type: none"> • Halt operations • Damage assets • Raise hazard risk • Pressure on WQ • Inundation risk 	<ul style="list-style-type: none"> • Extraction • Transportation • Processing • Ore processing • Enviro-compliance • Tailings management 	<ul style="list-style-type: none"> • Disrupted schedules <ul style="list-style-type: none"> • Safety impacts • Recovery costs • Resource competition <ul style="list-style-type: none"> • Pollution risk • Legal liability 	<ul style="list-style-type: none"> • Climate modeling • Hazard mapping • Improved drainage • Improve efficiency • Alternative sources <ul style="list-style-type: none"> • Community collaboration



After Bulovic, N., McIntyre, N. and Trancoso, R., 2024. Climate change risks to mine closure. *Journal of Cleaner Production*, 465, p.142697.

Water balance model

$$P = Q + ET + \Delta S$$

where,

- P = precipitation (in),
- Q = runoff (in),
- ET = evaporation (in), and
- ΔS = the change in storage.

Soil erosion

R-factor over T number of years:

$$R - factor_t = \frac{1}{T} \sum \left(\sum_{j=1}^{12} \hat{E}_j \right)$$

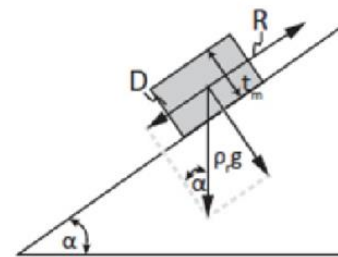
Flood risk

$$RX100_{ay_t} = \frac{1}{T} \sum \max\{R(k) : k = 1 \dots 365\} \quad (6)$$

Where R is the daily precipitation intensity for each day k across a year, whilst T is the number of years in analysis period t .

Slope stability

$$F_s = \frac{c' + (\gamma - m \gamma_w) z \cos^2 \beta \tan \phi'}{\gamma z \sin \beta \cos \beta}$$



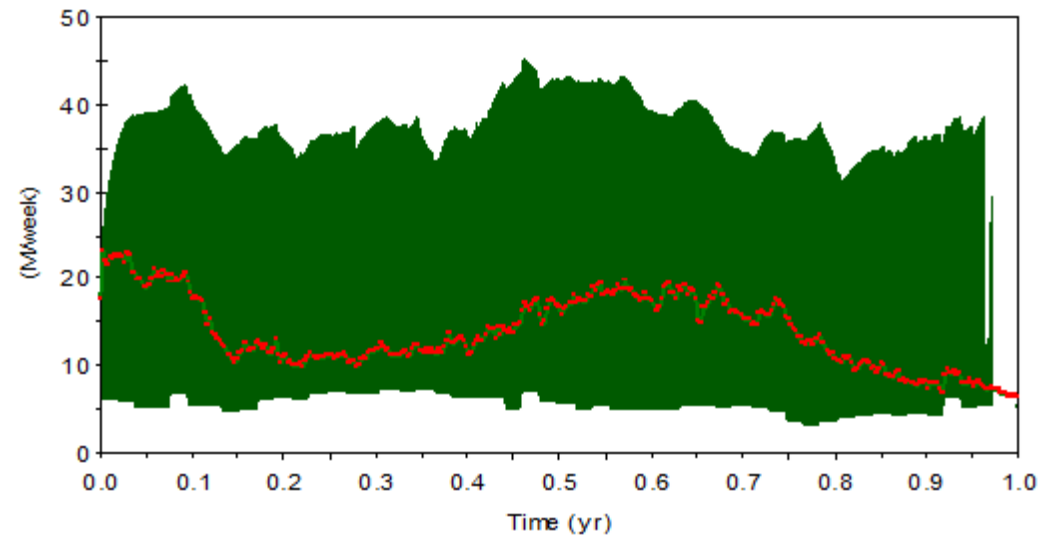
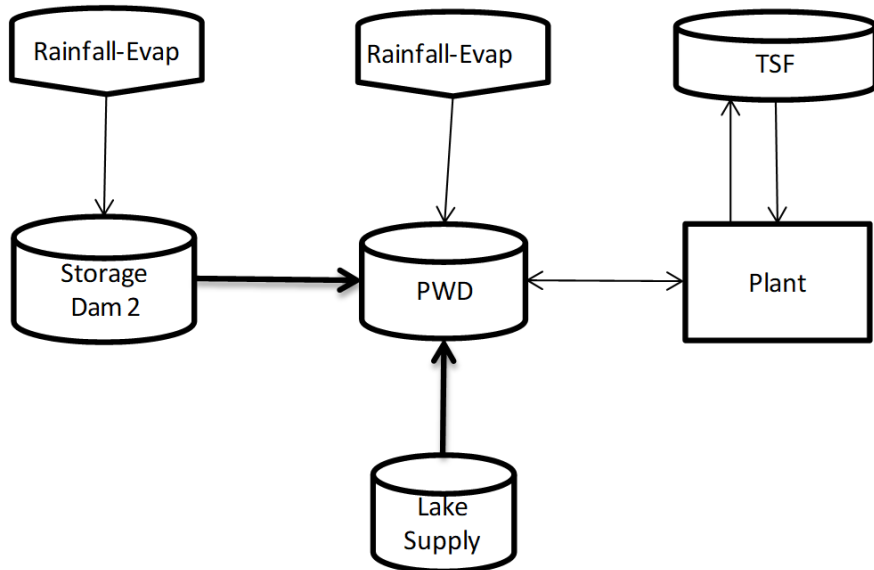
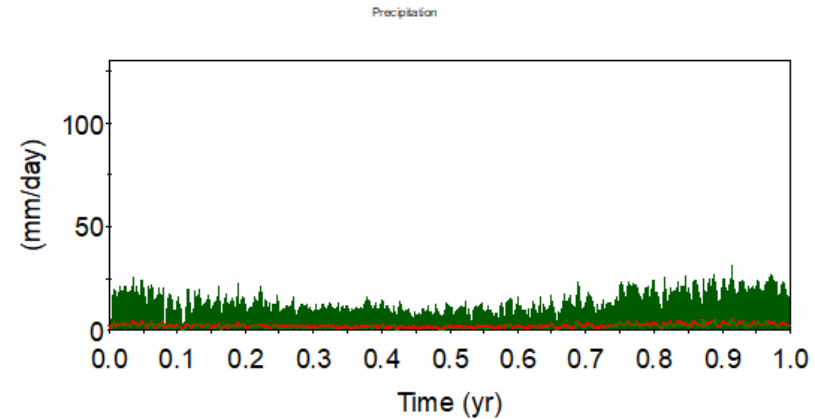
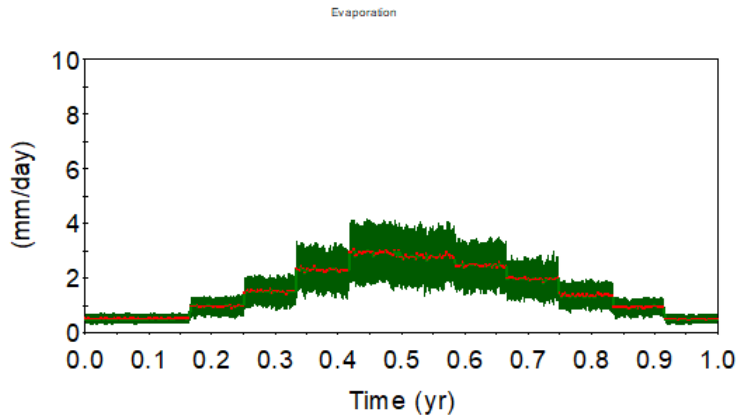
- F_s = factor of safety (dimensionless)
- c' = cohesion ($C_s + C_r$) kNm^{-2}
- m = water table as a proportion of soil thickness z (dimensionless)
- γ = unit weight of soil (bulk density of soil $\times 9.81$) kN m^{-3}
- γ_w = unit weight of water (bulk density of water $\times 9.81$) kN m^{-3}
- z = soil depth
- β = slope angle (deg)
- ϕ' = angle of friction (deg)

Water balance models

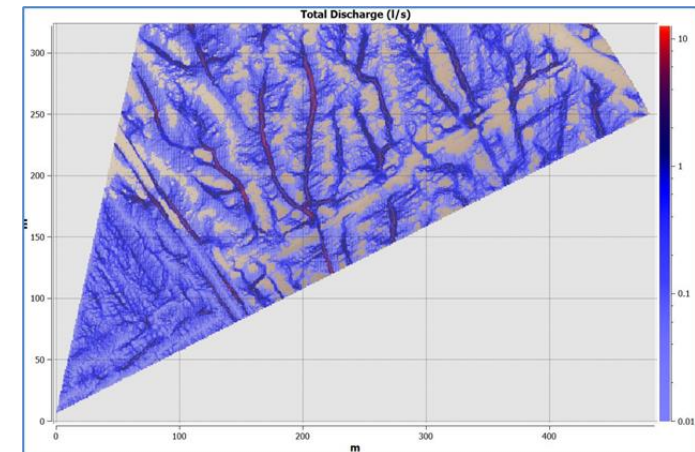
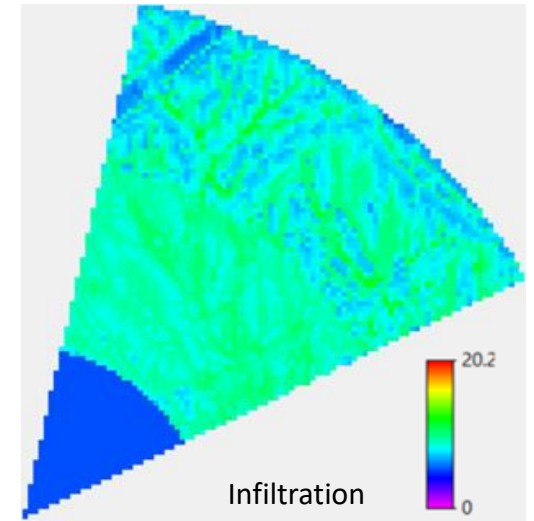
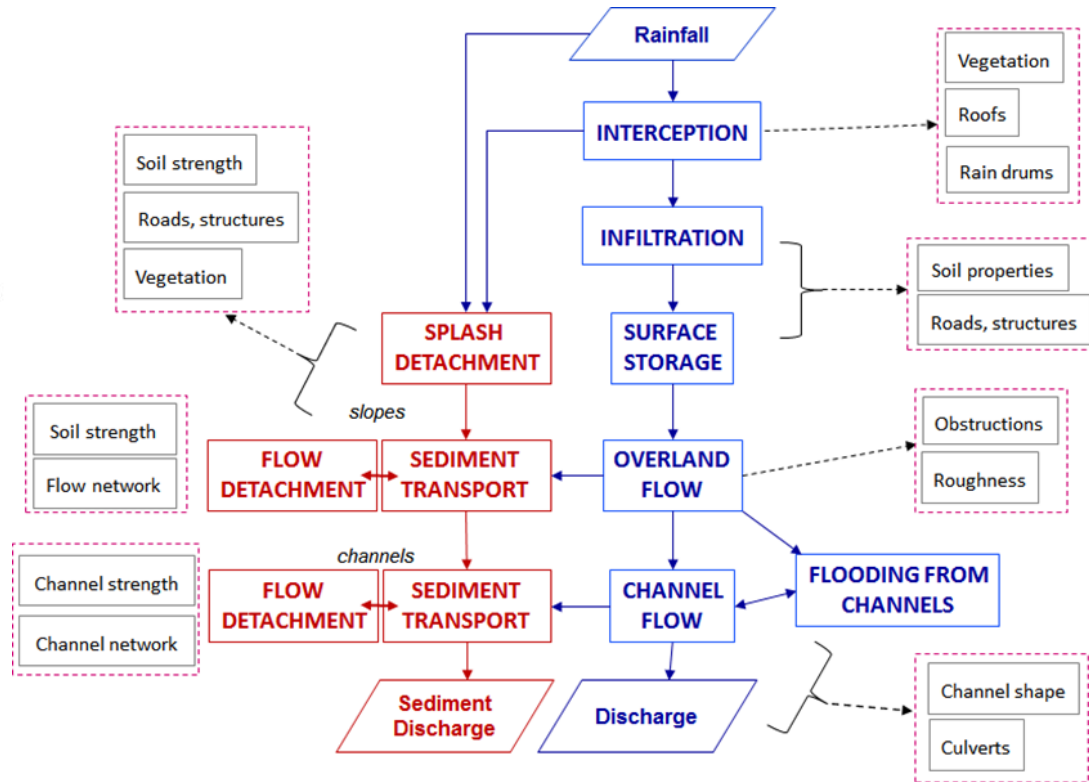
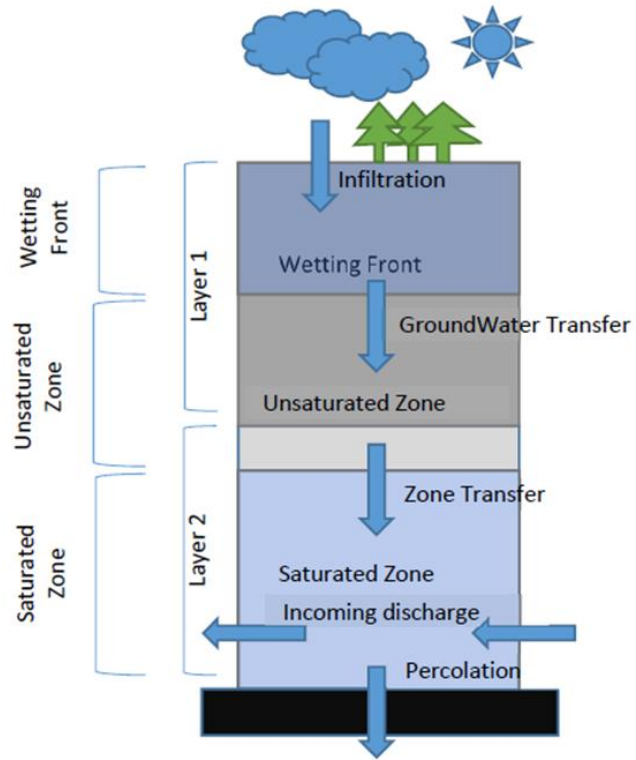
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- ET = evaporation (in), and
- ΔS = the change in storage.

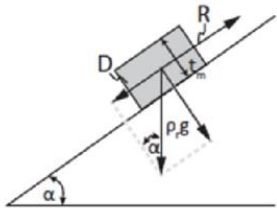


Soil erosion

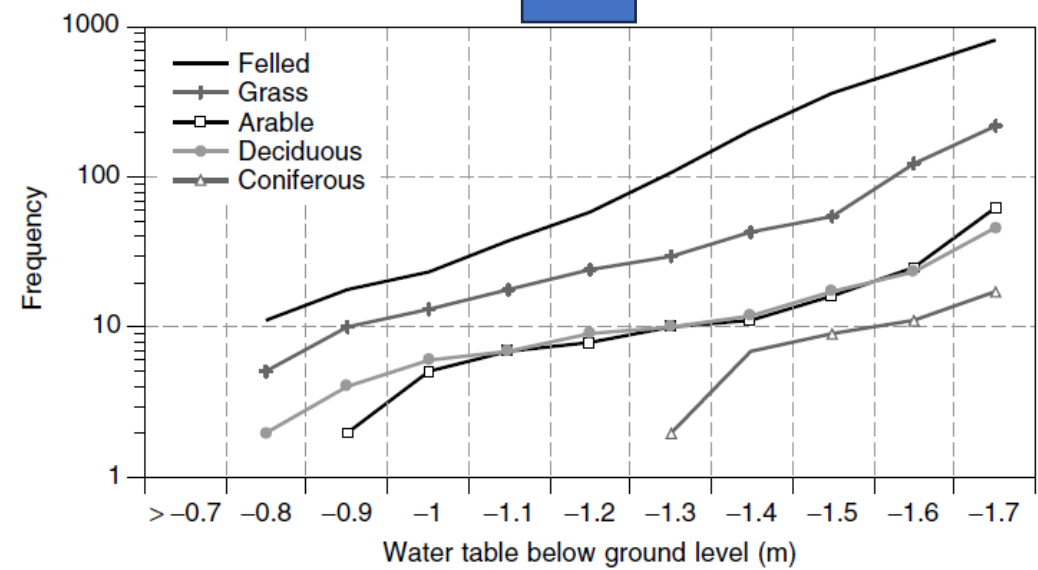
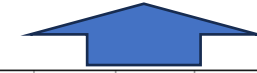
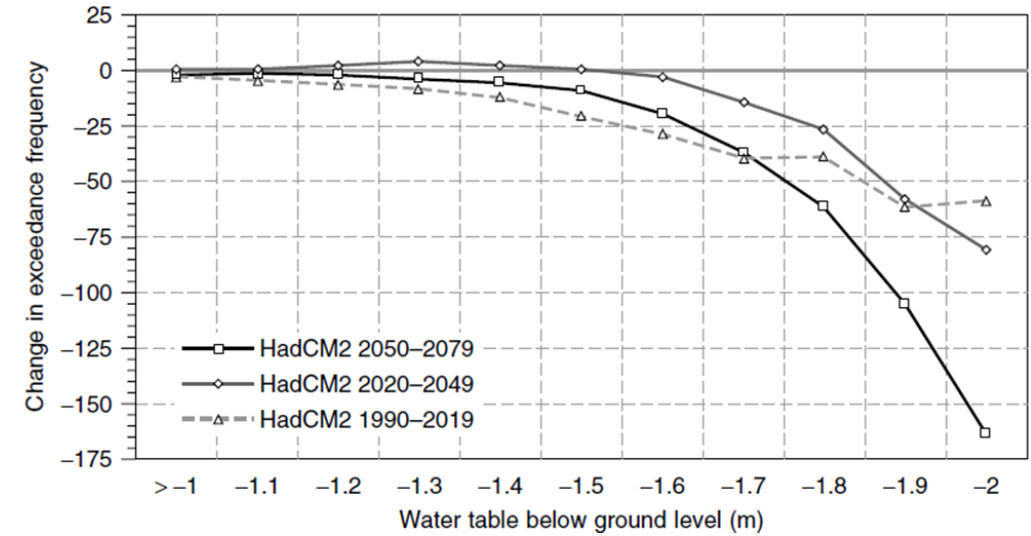


Slope stability

$$F_s = \frac{c' + (\gamma - m \gamma_w) z \cos^2 \beta \tan \phi'}{\gamma z \sin \beta \cos \beta}$$



- F_s = factor of safety (dimensionless)
- c' = cohesion ($C_s + C_r$) kNm^{-2}
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- ϕ' = angle of friction (deg)



Flood Risk

- High Intensity Rainfall Design System (HIRDS)
- Recalculation of flood frequency curves

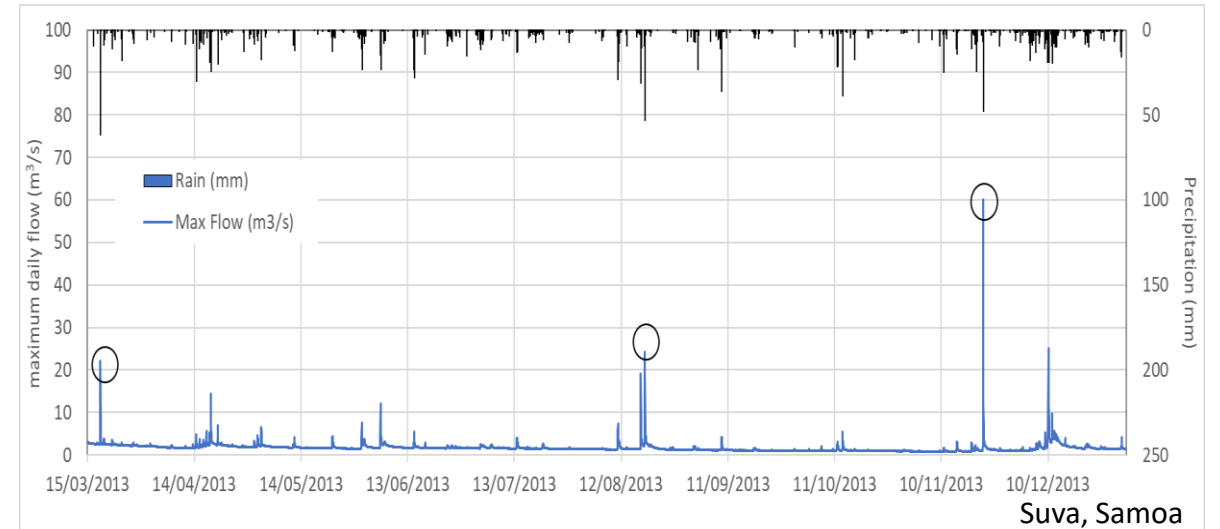
NIWA High Intensity Rainfall Design System V4

Location

Address search Enter your address and press enter to search

Site ID: F11682
 Site Name: DOWNTOWN
 Data Source: cliffs.niwa.co.nz
 Location: 171.894, -41.658

Rainfall records used for different event durations:
 Daily Coverage: 1945-1996 (44yrs)
 Sub-Daily Coverage: No Data
 Sub-Hourly Coverage: No Data

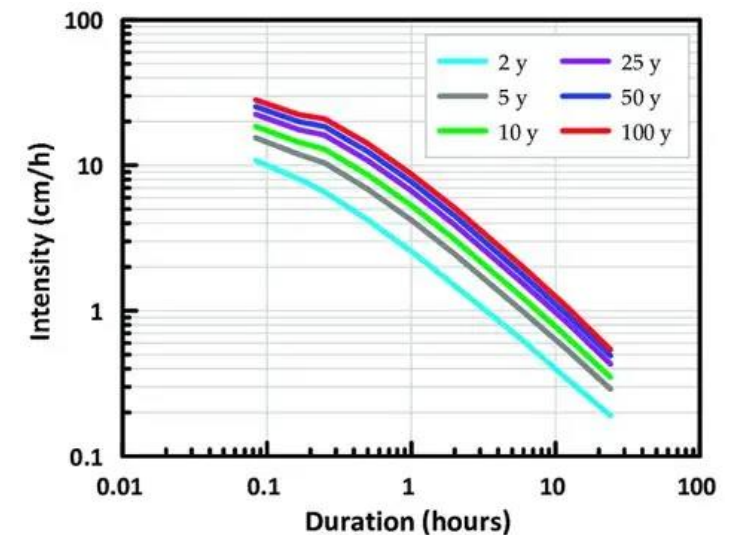


Rainfall depths (mm) :: RCP2.6 for the period 2031-2050

ARI	AEP	10m	20m	30m	1h	2h	6h	12h	24h	48h	72h	96h	120h
1.58	0.633	7.21	11.9	16	26.6	43.9	91.7	138	198	265	303	327	343
2	0.5	7.94	13	17.5	29.2	48	99.9	151	215	287	327	353	370
5	0.2	10.5	17.1	22.9	37.9	61.9	128	191	271	359	408	439	460
10	0.1	12.4	20.2	27	44.4	72.3	148	221	311	411	466	500	523
20	0.05	14.5	23.4	31.3	51.2	82.9	169	250	351	462	523	560	584
30	0.033	15.8	25.4	33.8	55.3	89.3	181	268	375	492	556	595	621
40	0.025	16.7	26.9	35.7	58.2	93.9	190	281	392	514	580	620	646
50	0.02	17.4	28	37.2	60.6	97.6	197	290	405	530	598	640	666
60	0.017	18	28.9	38.4	62.5	101	203	299	416	544	613	655	682
80	0.013	19	30.4	40.4	65.6	105	211	311	433	565	636	679	707
100	0.01	19.7	31.6	41.9	68	109	219	321	447	581	654	698	726
250	0.004	22.9	36.5	48.3	77.9	124	247	361	499	647	725	772	802

Rainfall depths (mm) :: RCP2.6 for the period 2081-2100

ARI	AEP	10m	20m	30m	1h	2h	6h	12h	24h	48h	72h	96h	120h
1.58	0.633	7.21	11.9	16	26.6	43.9	91.7	138	198	265	303	327	343
2	0.5	7.94	13	17.5	29.2	48	99.9	151	215	287	327	353	370
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250	0.004	22.9	36.5	48.3	77.9	124	247	361	499	647	725	772	802



Take-away messages

- Increased variation in climatic variability results in increased operational risks (i.e. the ability to meet licensed discharge and abstraction compliance).
- Site-scale climate impact mitigation should be based on accurate water-balance and characterisation of a site's current and future hydrological condition
- Mitigation strategies need to relate to management of water processes, water storage, and evaporation losses.
- At very least should represent changes in average, wet and dry years. But preferably also at changes in variability, duration and magnitude.



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